Introduction to Machine Learning

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Thanks to the slides of Prof. P. Domingos from Washington University, Prof. H.-T. Lin and Prof. Lee Hung-Yi Lee from NTU.

Outline

- Introduction to Machin Learning
  - Supervised Learning
  - Unsupervised Learning
  - Semi-supervised Learning
  - Reinforcement Learning
  - Generative Adversarial Network
  - 生成對抗網路

AI is so Easy

Like gardening

- **Seeds** = Algorithms
- **Nutrients** = Data
- **Gardener** = You
- **Plants** = Programs

You can do it!

Data Mining = AI Algorithm?

- Dig out invisible but invaluable minerals.
- Data mining is dig out meaningful information from meaningless data.

- Walmart

- Association rule
- =>Find「pattern」 but no intelligence

Learning is to find a function

- Voice Recognition

f() = 鳥叫聲

- Speech Recognition

f() = “我不知道你說什麼”

- Image recognition

f() = “Seafood”

- Channel estimation

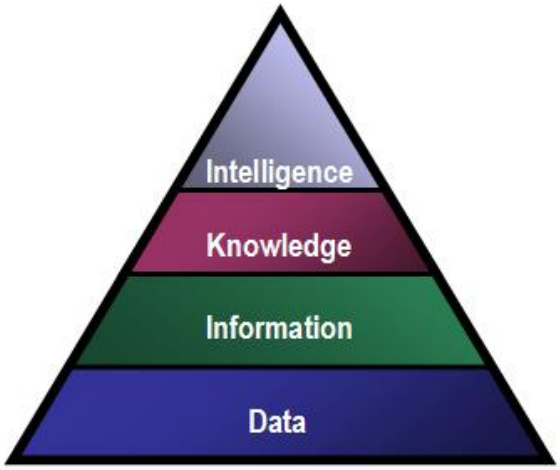
f(

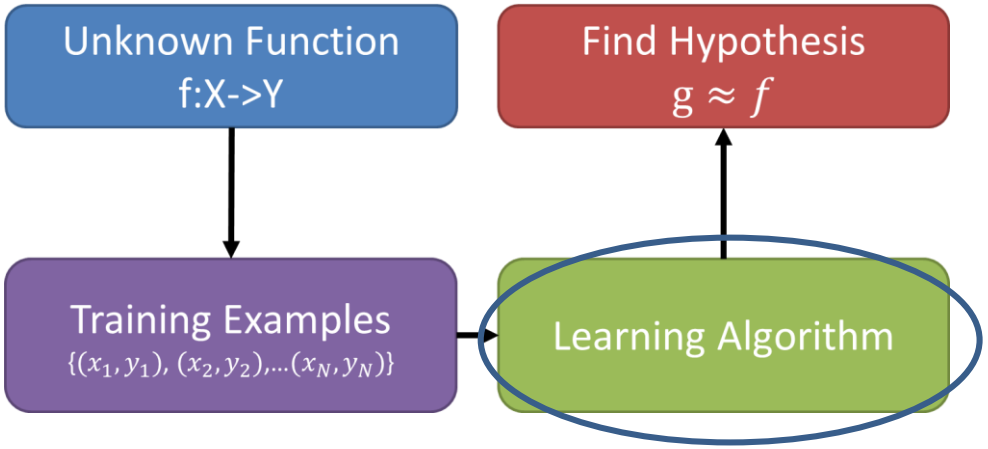
) = Channel parameters

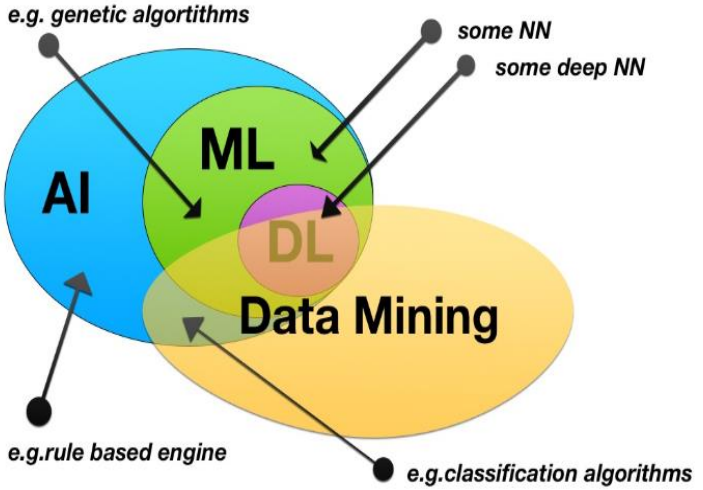
http://cdn1.itpro.co.uk/sites/itpro/files/images/dir_176/it_photo_88225.jpg
http://www.berkeleywellness.com/sites/default/files/field/image/ThinkstockPhotos-520490716_field_img_hero_988_380.jp
https://telcoantennas.com.au/site/sites/default/files/images/4G-cross-polarisation-low-signal-areas.png

There are many methods to learn!

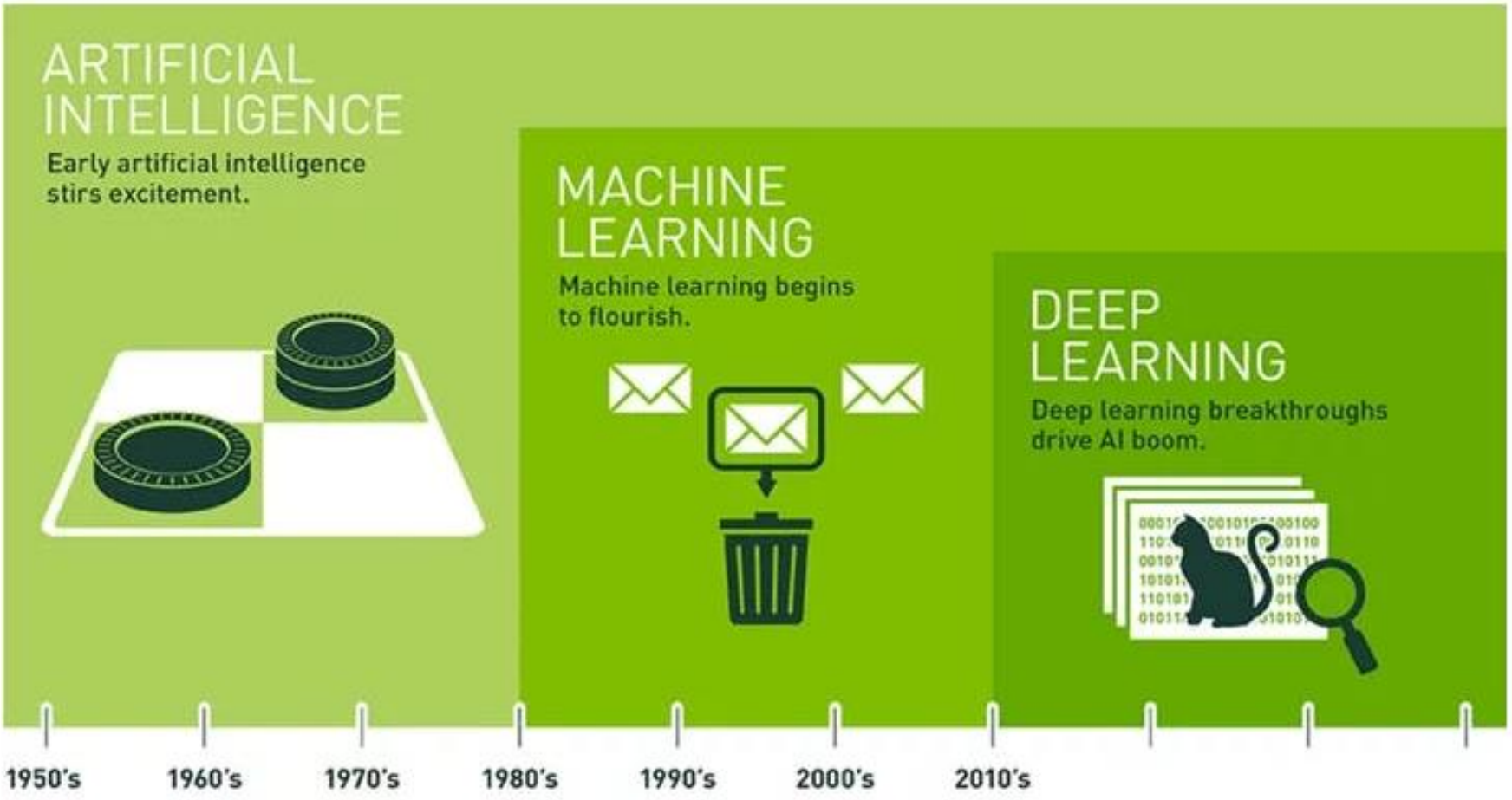
- Learning is to find a function!!
- How do we find the function?
- There are many learning algorithms.







AI, ML, DL



圖片來源：NVIDIA

Machine Learning

- Machine Learning
  - 通過演算法來分析數據、從中學習找到一個函式，來判斷或預測現實世界裡的某些事
  - 並非手動編寫帶有特定指令的軟體程序來完成某個特殊任務
  - 是使用大量的資料和演算法來「訓練」機器，讓它學習如何執行任務。

- Tens of thousands of machine learning algorithms
- Hundreds new every year
- Every machine learning algorithm has three components:
  - **Representation**
  - **Evaluation**
  - **Optimization**

Representation

- Decision trees
- Sets of rules / Logic programs
- Instances
- Graphical models (Bayes/Markov nets)
- Neural networks
- Support vector machines
- Model ensembles
- Etc.

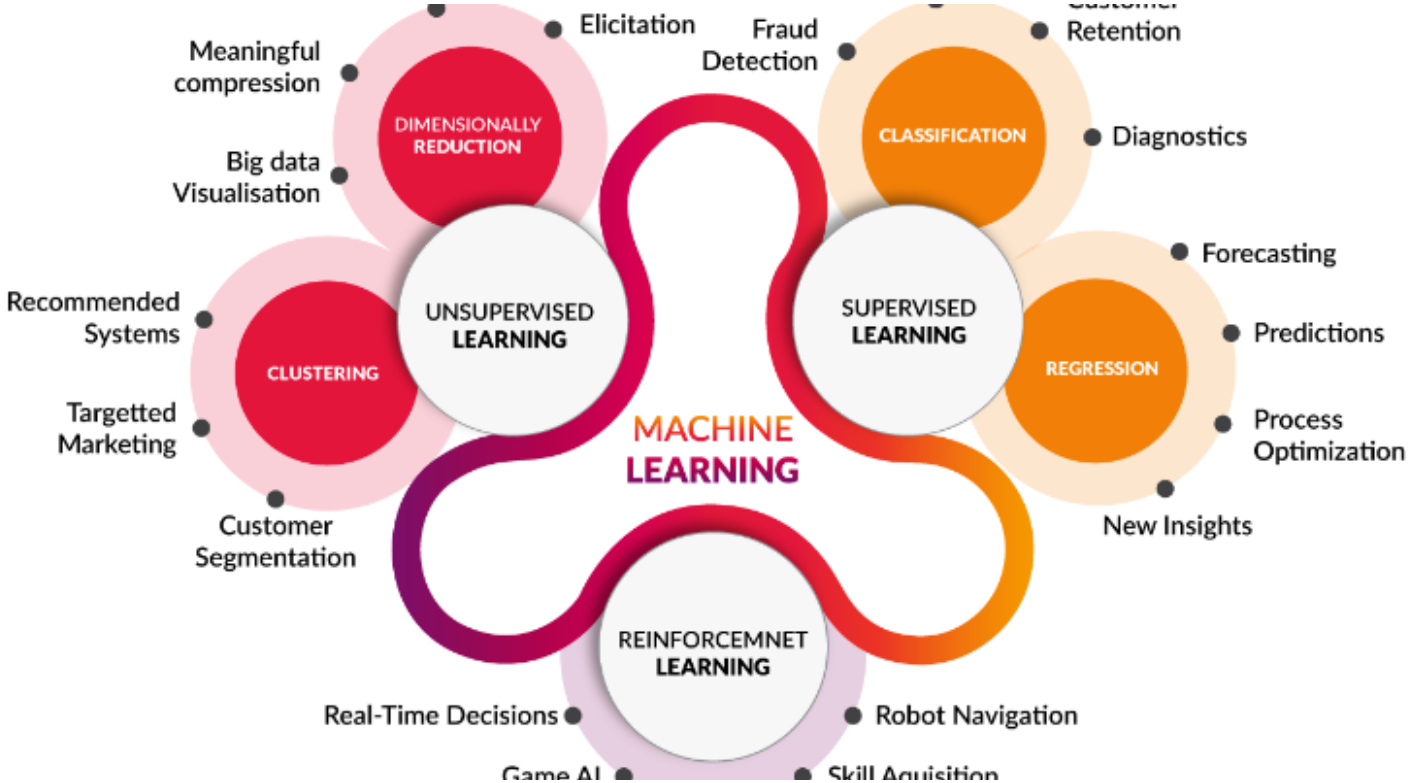
Evaluation

- Accuracy
- Precision and recall
- Squared error
- Likelihood
- Posterior probability
- Cost / Utility
- Margin
- Entropy
- K-L divergence
- Etc.

Optimization

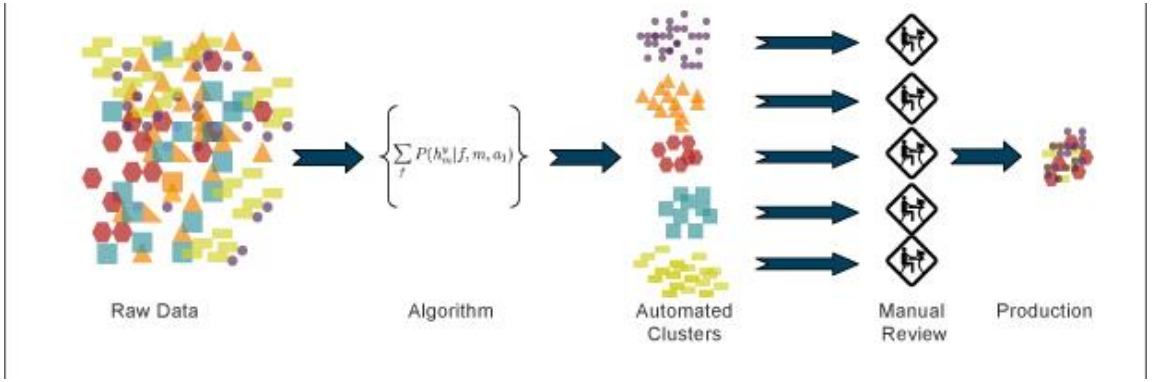
- Combinatorial optimization
  - E.g.: Greedy search
- Convex optimization
  - E.g.: Gradient descent
- Constrained optimization
  - E.g.: Linear programming

Representation



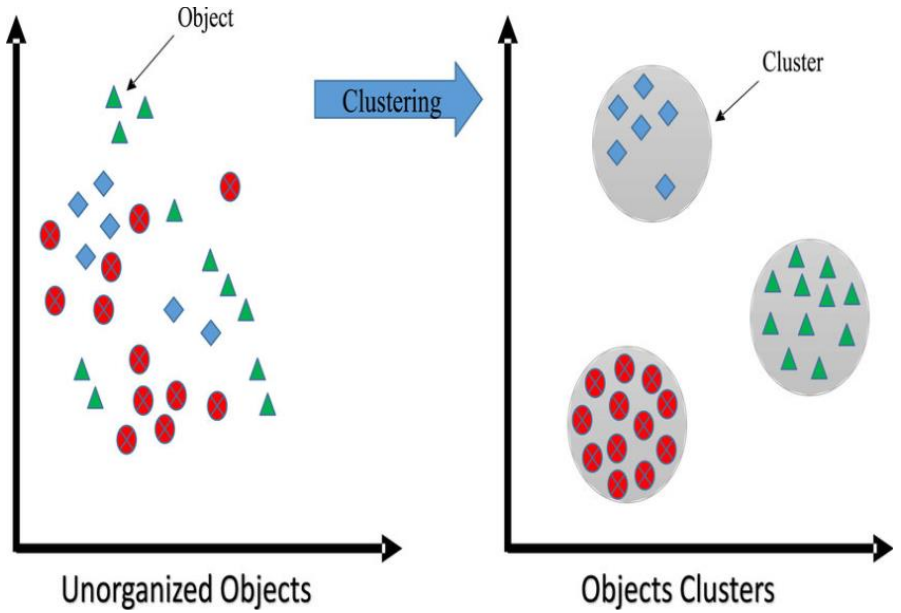
Unsupervised Learning (1/2)

- Unsupervised Learning is the second type of machine learning, in which unlabeled data are used to train the algorithm, which means it used against data that has no historical labels.
- The purpose is to explore the data and find some structure within.
  - Clustering
  - Anomaly Detection
  - Association Rule
  - Autoencoder



Unsupervised Learning (2/2)

- Clustering



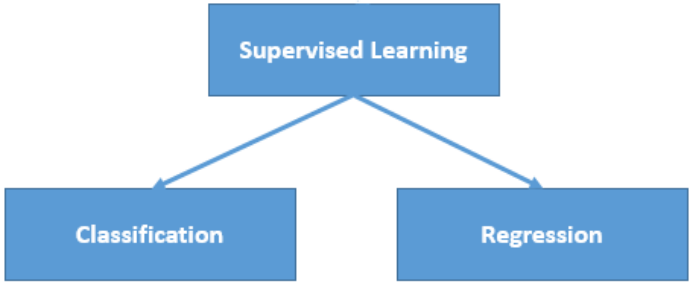
- Association Rule

摩根大通應用非監督去降低業務流程

- 早期創業家尋求銀行貸款，第一印象通常是最重要的，但是也因為資訊的缺乏造成銀行職員誤判的結果。
- 為了使日常工作自動化並減少分析業務往來所需的時間及錯誤，摩根大通開發了一種專有的ML算法，稱為Contract Intelligence或COiN。
- COiN的工作就是自動執行特定類別的文件審查，採用圖像辨識來識別文件中的模式，而背後的演算法即使用了無監督學習。
- 演算法通過分析各個銀行契約中的數據，並抓出既定模式，COiN可以將條款細分為150種不同的信用貸款契約，並從中擷取重要的訊息。
- COiN不僅可以在幾秒內處理12,000個信貸協議，更是讓銀行省下了360,000個工時。

https://oosga.com/thinking/difference-between-supervised-learning-and-unsupervised-learning/

Supervised Learning



- With labeled data
- ***Regression***
  - The type of Supervised Learning in which labelled data used, and this data is used to make predictions in a continuous form.
  - The output of the input is always ongoing, and the graph is linear.
  - EX: House Price Prediction
- **Classification**
  - The type of Supervised Learning in which labelled data can use, and this data is used to make predictions in a non-continuous form.
  - The output of the information is not always continuous, and the graph is non-linear.
  - EX: check whether the email is spam or not spam.

https://towardsdatascience.com/machine-learning-for-beginners-d247a9420dab

Regression Example

Regression

The output of the target function f is "scalar".

Predict PM2.5

Training Data:

Input:

9/01 PM2.5 = 63 9/02 PM2.5 = 65

Output:

9/03 PM2.5 = 100

Input:

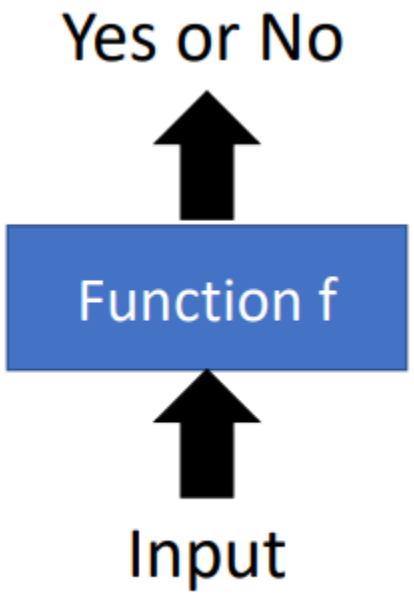
9/12 PM2.5 = 30 9/13 PM2.5 = 25

Output:

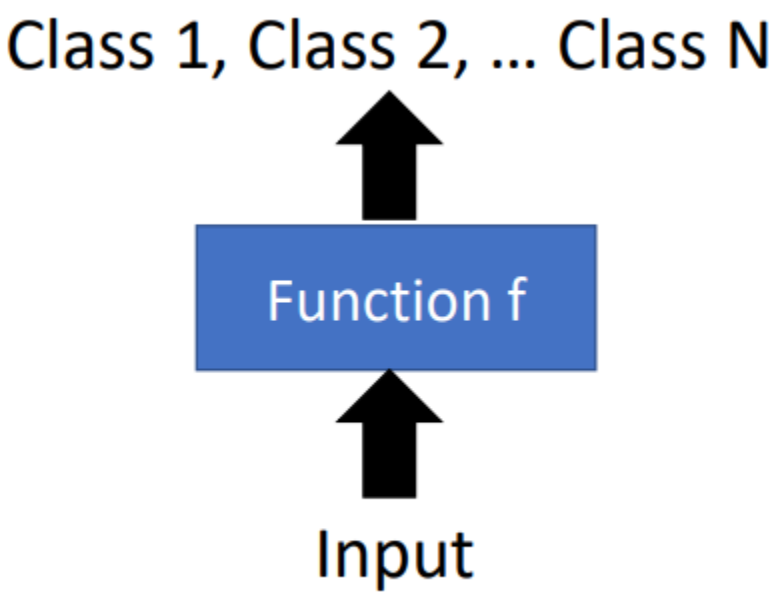
9/14 PM2.5 = 20

Classification Example

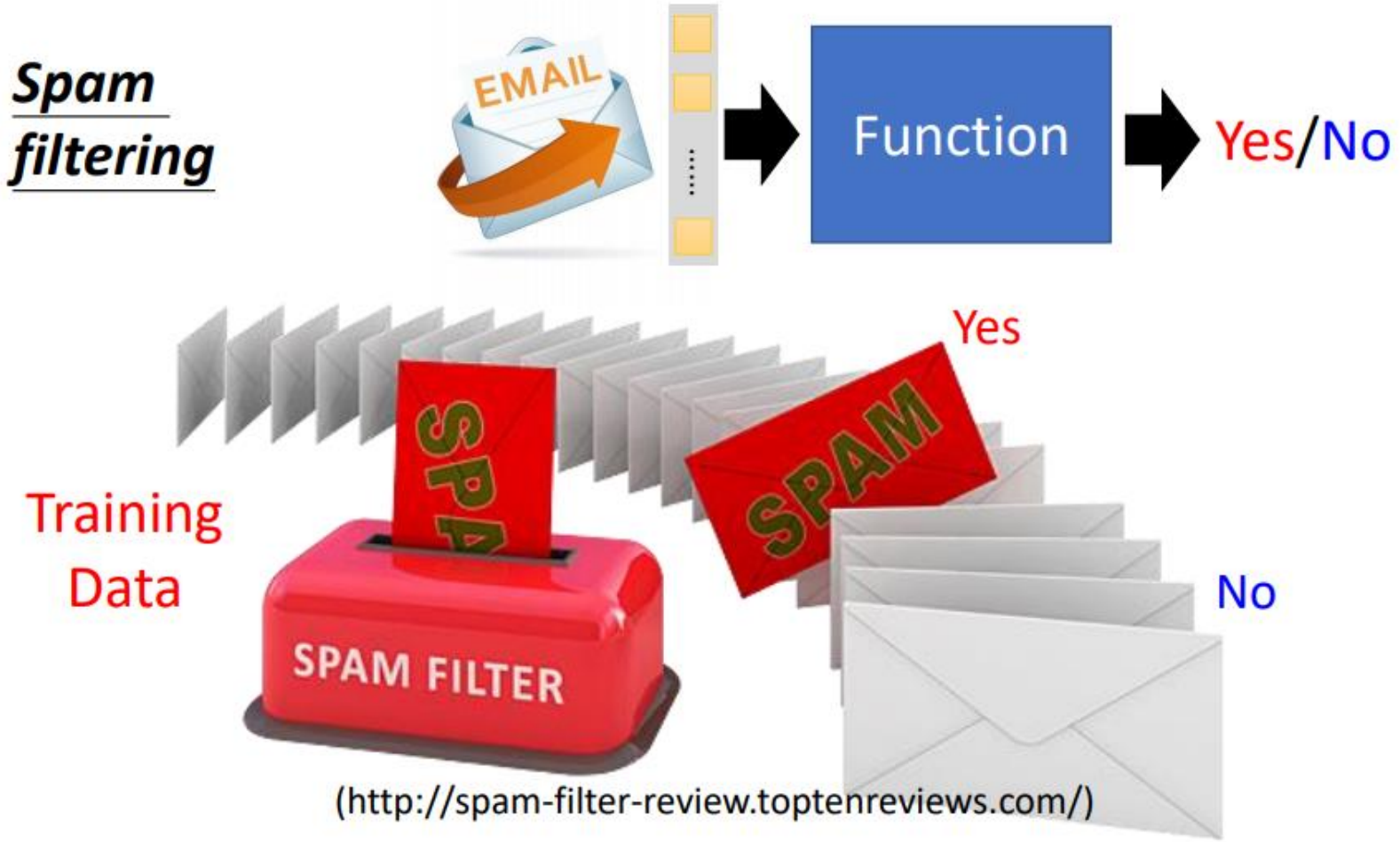
Binary Classification



Multi-class Classification

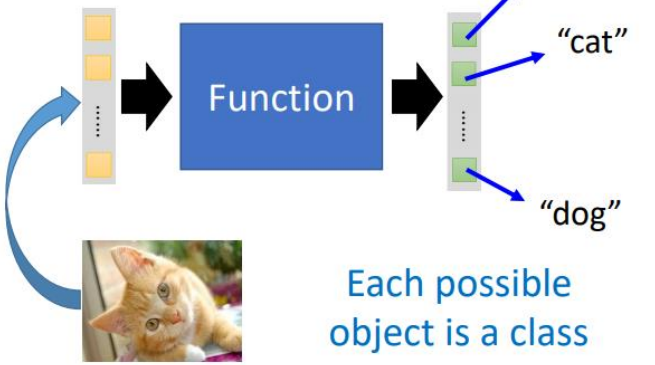


Binary Classification Example



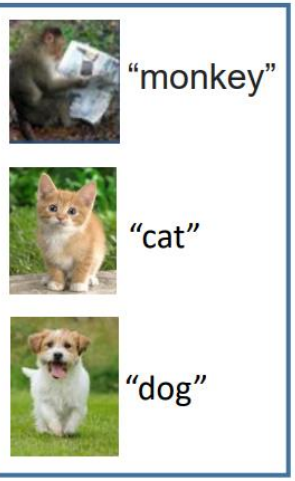
Multi-Classification Example

Image Recognition

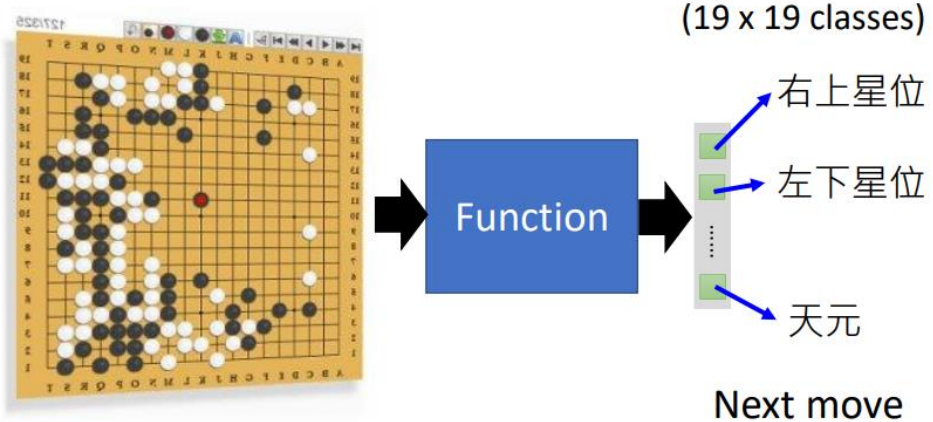


Each possible object is a class

Training Data



Playing GO



Each position is a class

(19 x 19 classes)

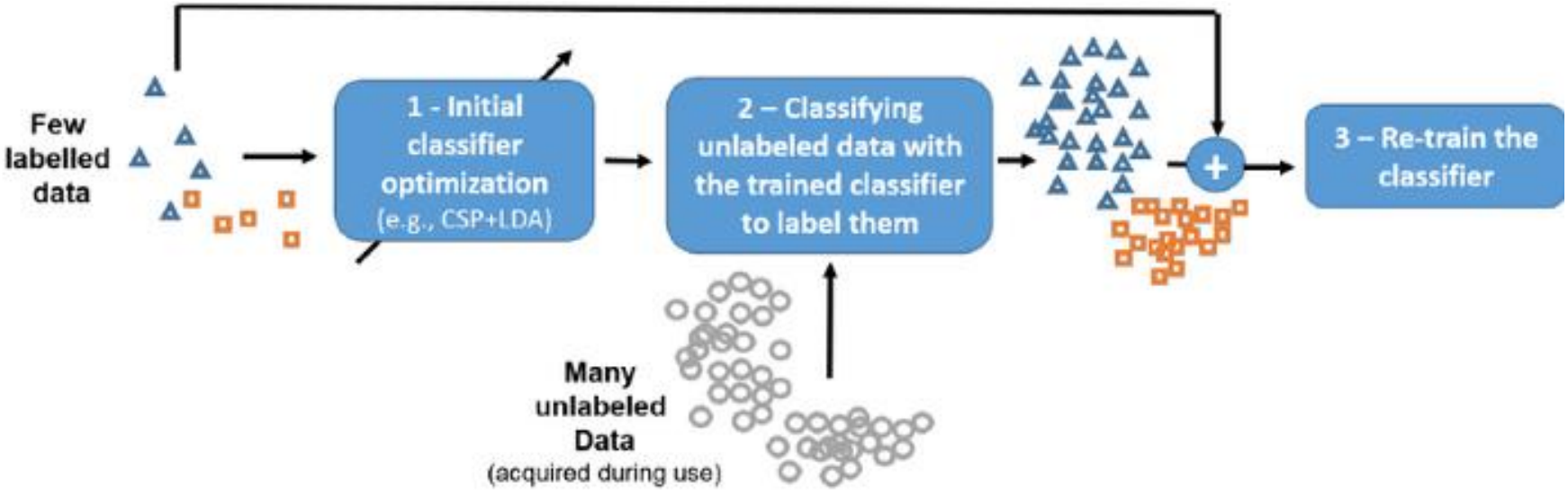
Object Detection

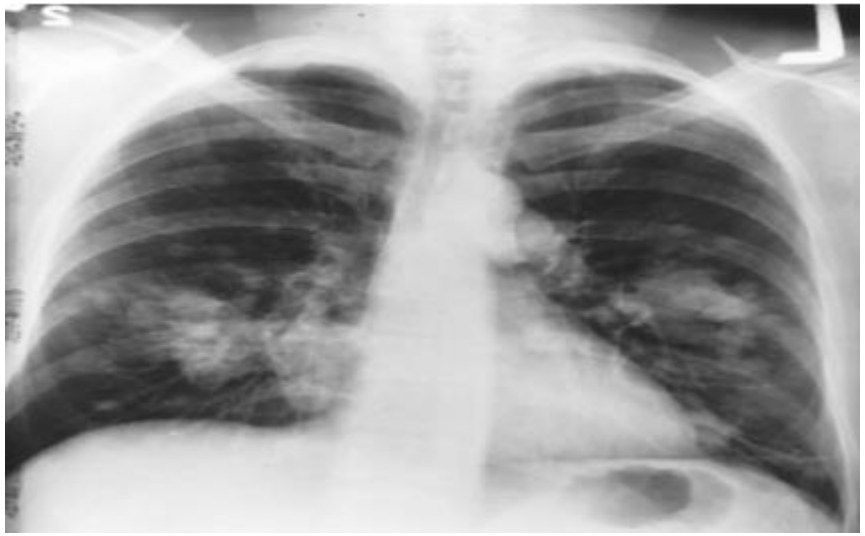
- Object detection of multiple classes

Semi-Supervised Learning (1/2)

- Both types of raw data used.
- Hybrid of supervised and unsupervised machine learning.
- The Semi-supervised employs both labelled and unlabeled data for training typically a small amount of labelled data with a significant amount of unlabeled data.
- Labelling massive amounts of data
  - Time-consuming
  - Expensive.
  - Human biases on the model
- Include lots of unlabeled data
  - Improve the accuracy of the final model while reducing the time and cost spent building it.

Semi-Supervised Learning (2/2)





小結

監督式學習	非監督式學習	半監督式學習
• 需要有標記(Labeled)的數據 • 可用於迴歸分析 (數值的預測) • 可用於分群分析 (分類)	• 需要無標記(Labeled)的數據 • 可用於分群分析 (分類) • 用於在數據中的尋找既定模式的情況	• 結合有標記與未標記的數據 • 出於有標記數據的獲取困難或成本較高 • 可以有效提升模型的正確率
• 線性回歸 (Linear regression) • 單純貝式 (Naive bayes) • 決策樹 (Decision Tree)	• 集群分析 (K-means clustering) • 混和模型 (Gaussian mixture)	• 先利用監督式學習訓練，之後在加上無標記的數據。
• 優化定價策略、預估價格彈性、以及市場動態	• 判斷信用交易、保險金融等活動是否異常（詐欺）	• 可用於自然語言處裡，以強化準確性

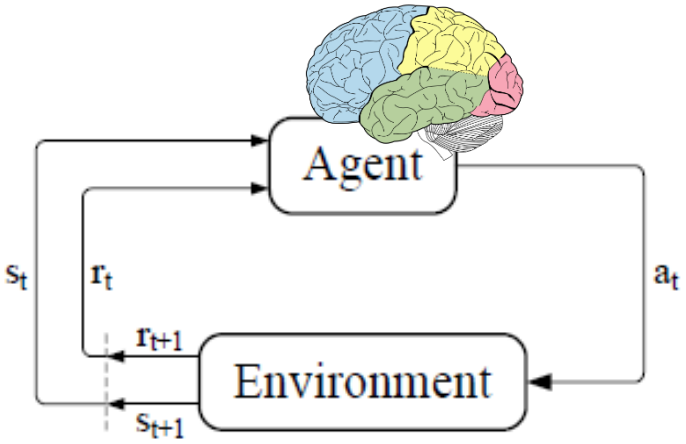
Reinforcement Learning

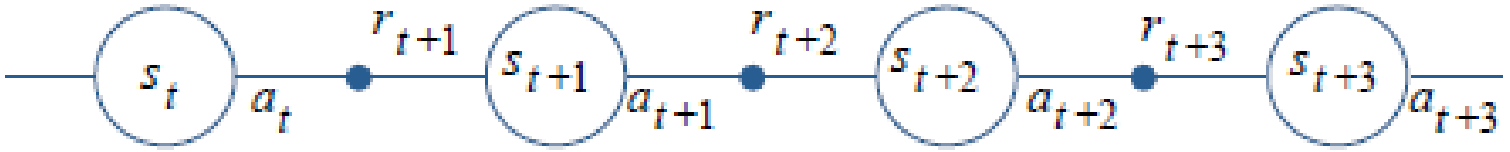
- No raw data is given as input.
- Reinforcement learning algorithm have to figures out the situation on their own.
- Frequently used for robotics, gaming, and navigation.
- With reinforcement learning, the algorithm discovers through trial and error which actions yield the most significant rewards.
- Three components:
  - Agent: the learner or decision maker.
  - Environment: everything the agent interacts with.
  - Actions: what the agent can do.

Interaction between Agent and Environment

- Agent interacts at discrete time steps t = 0, 1, 2, …

- Observe state $s_t \in S$
- Selects action $a_t \in A(s_t)$
- Obtains immediate reward $r_{t+1} \in R$
- Observe resulting state s_{t+1}





Train an agent which can adapt to the environment.

How To Choose Action?

- Agent adopts “strategy” to choose actions.
- Two methods:
  - Exploration(探索): choose actions randomly
  - Exploitation(利用): choose best actions from past experience (Q-Table)

Q-table initialised at zero

	UP	DOWN	LEFT	RIGHT
0	0	0	0	0
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0

After few episodes

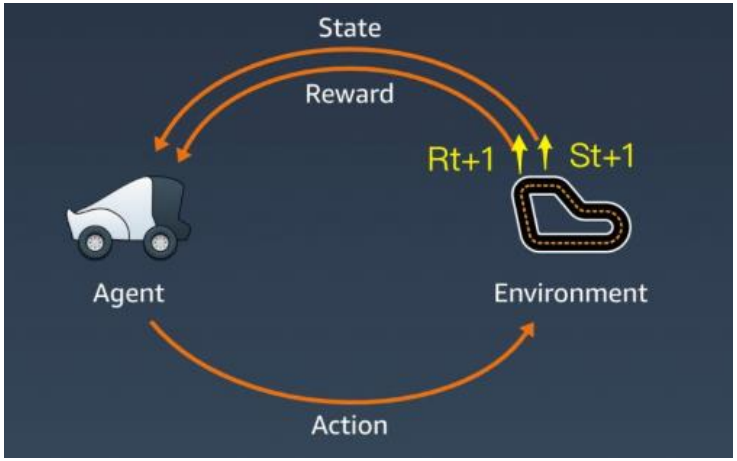
	UP	DOWN	LEFT	RIGHT
0	0	0	0	0
1	0	0	0	0
2	0	2.25	2.25	0
3	0	0	5	0
4	0	0	0	0
5	0	0	0	0
6	0	5	0	0
7	0	0	2.25	0
8	0	0	0	0

Eventually

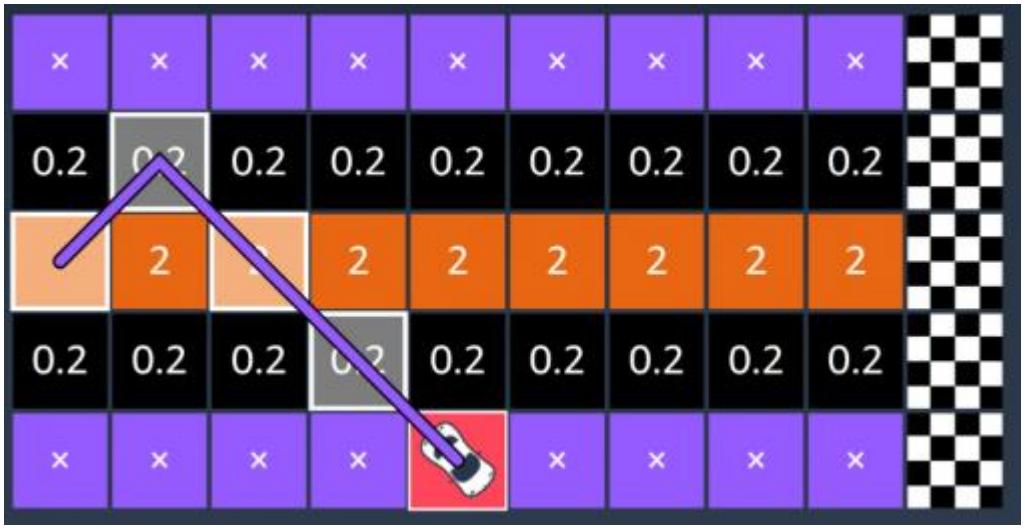
	UP	DOWN	LEFT	RIGHT
0	0	0	0.45	0
1	0	1.01	0	0
2	0	2.25	2.25	0
3	0	0	5	0
4	0	0	0	0
5	0	0	0	0
6	0	5	0	0
7	0	0	2.25	0
8	0	0	0	0

Reinforcement Learning Example

- Mission: Train the racing car to get used to the track.
  - Racing car: agent
  - Track: Environment
  - Policy: Action
- Maximize reward function.



First Try:



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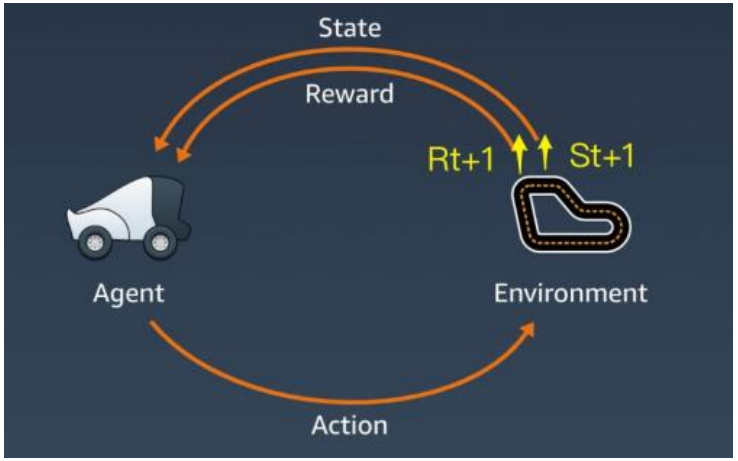
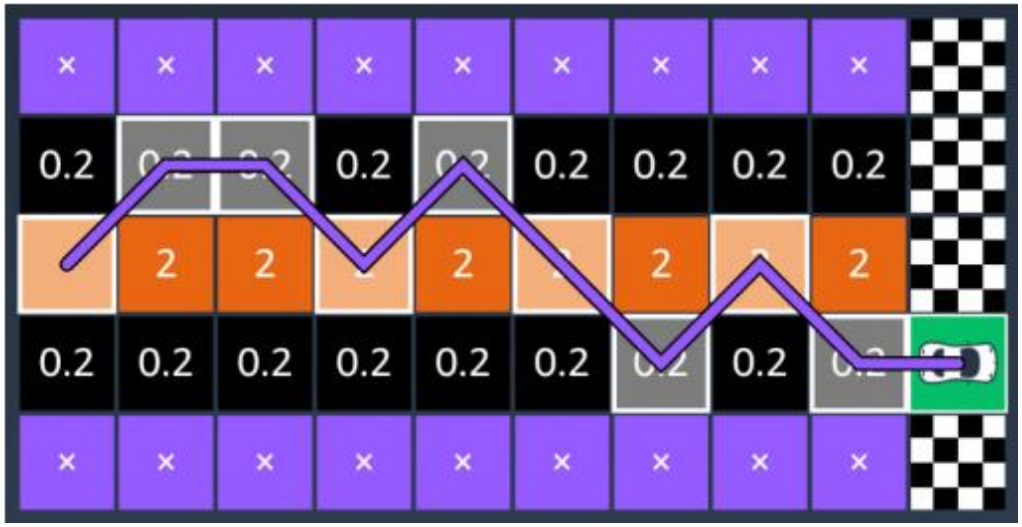


Second Try:



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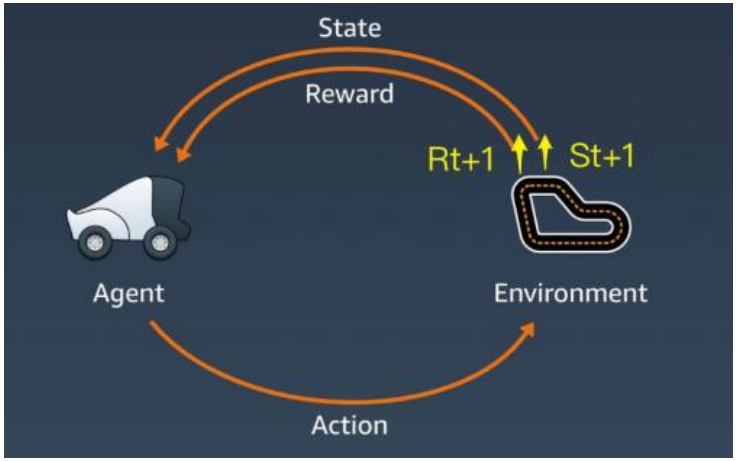
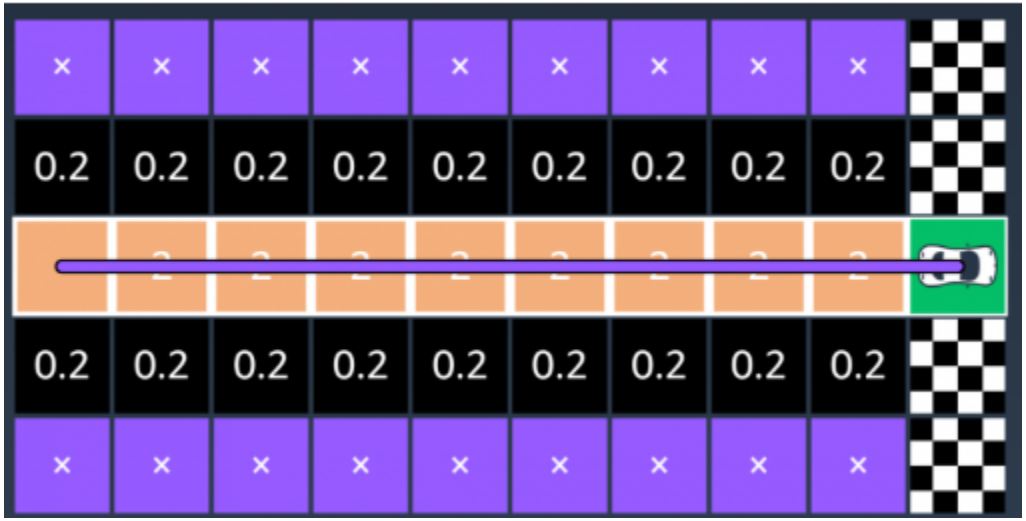
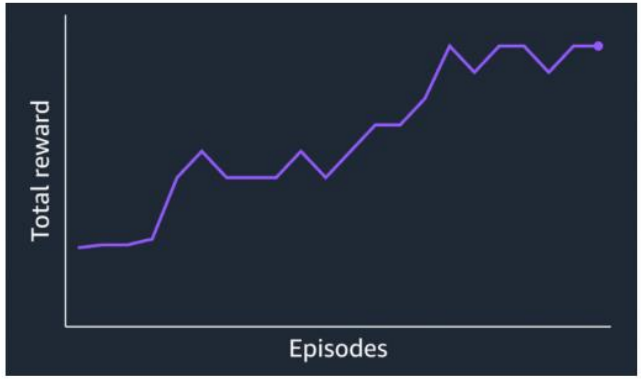


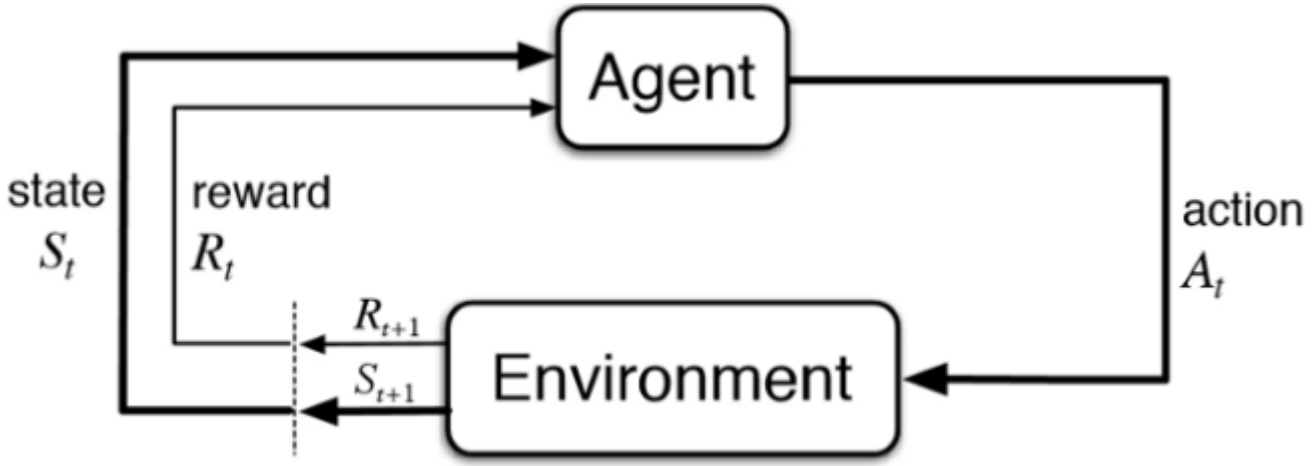
Third Try:





Objective

- The agent take actions that maximize the expected reward over a given measure of time.
- The agent will reach the goal much quicker by following a good policy.
- The purpose of reinforcement learning is to learn the best plan.



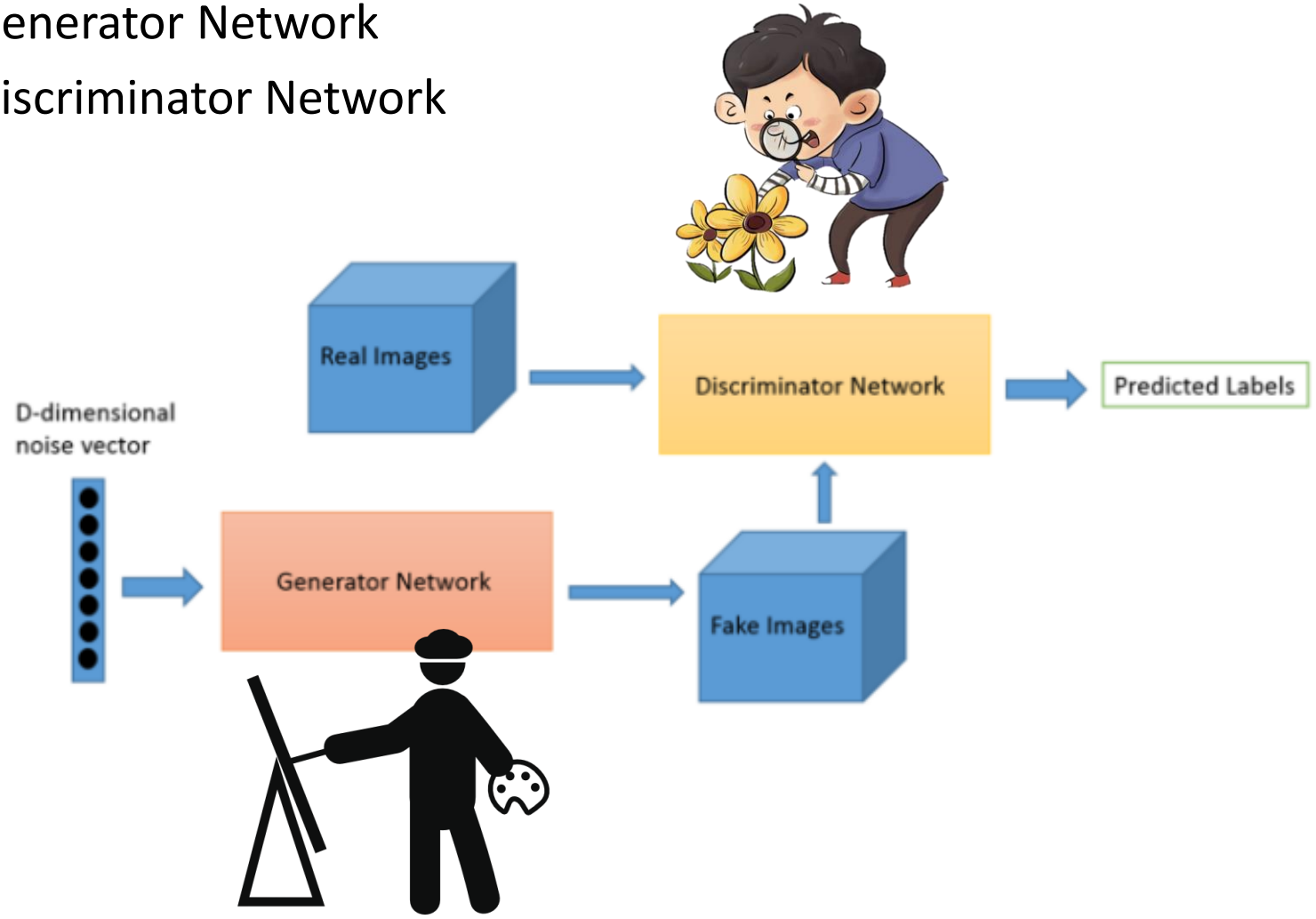
Generation

- Generate structured and complex data ex: image data

Generative Models: variational auto-encoder (VAE), generative adversarial network (GAN), Flow-based generative model, etc.

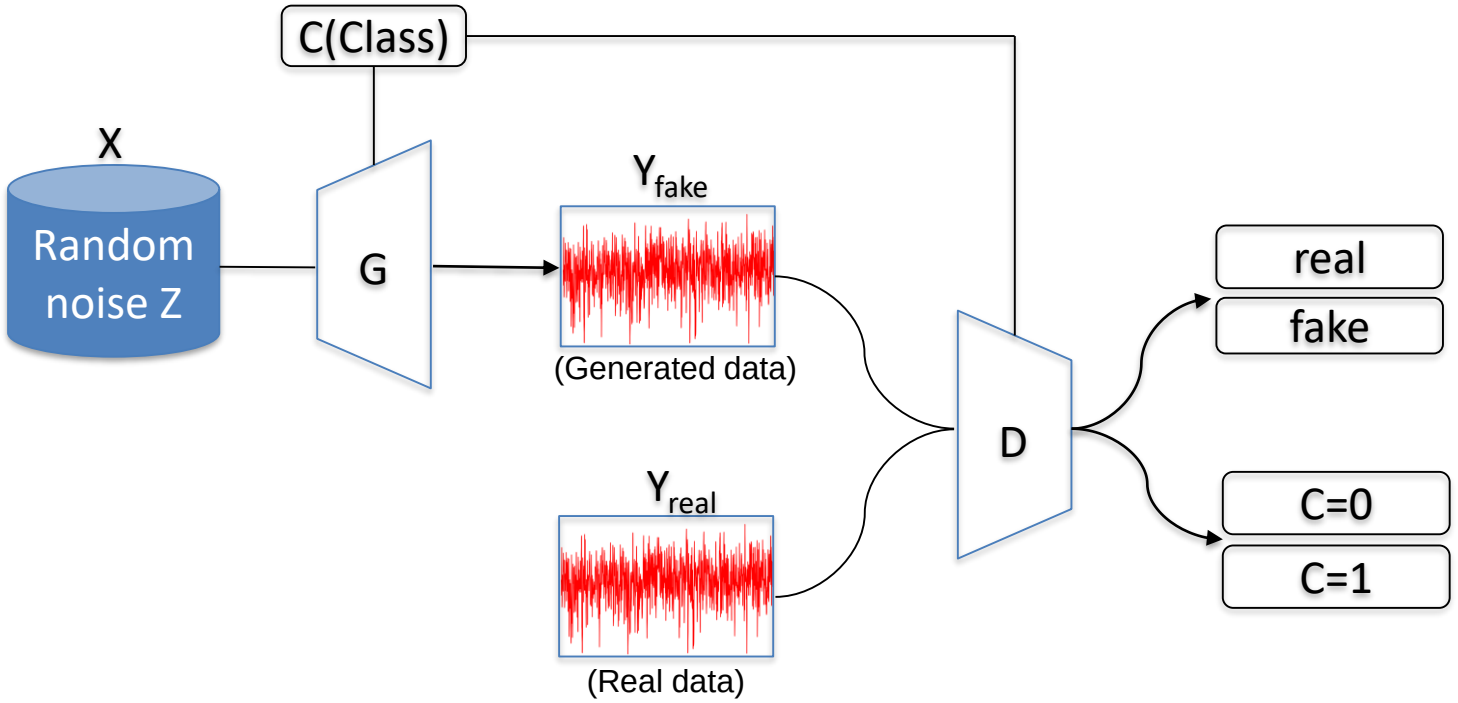
Generative Adversarial Network

- GAN:
  - Generator Network
  - Discriminator Network



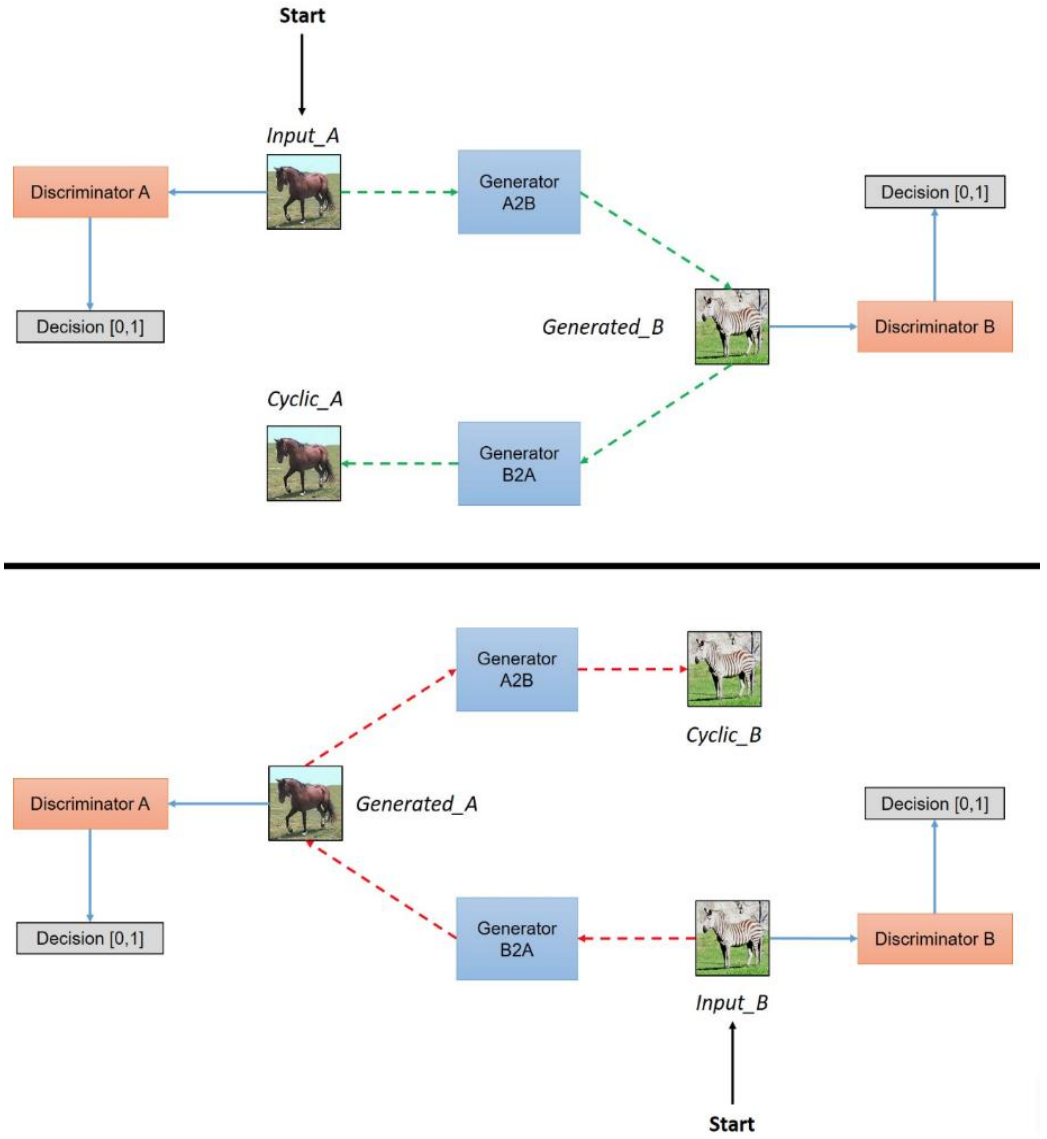
Auxiliary Classifier GAN (1/2)

- ACGAN: add classification into GAN.

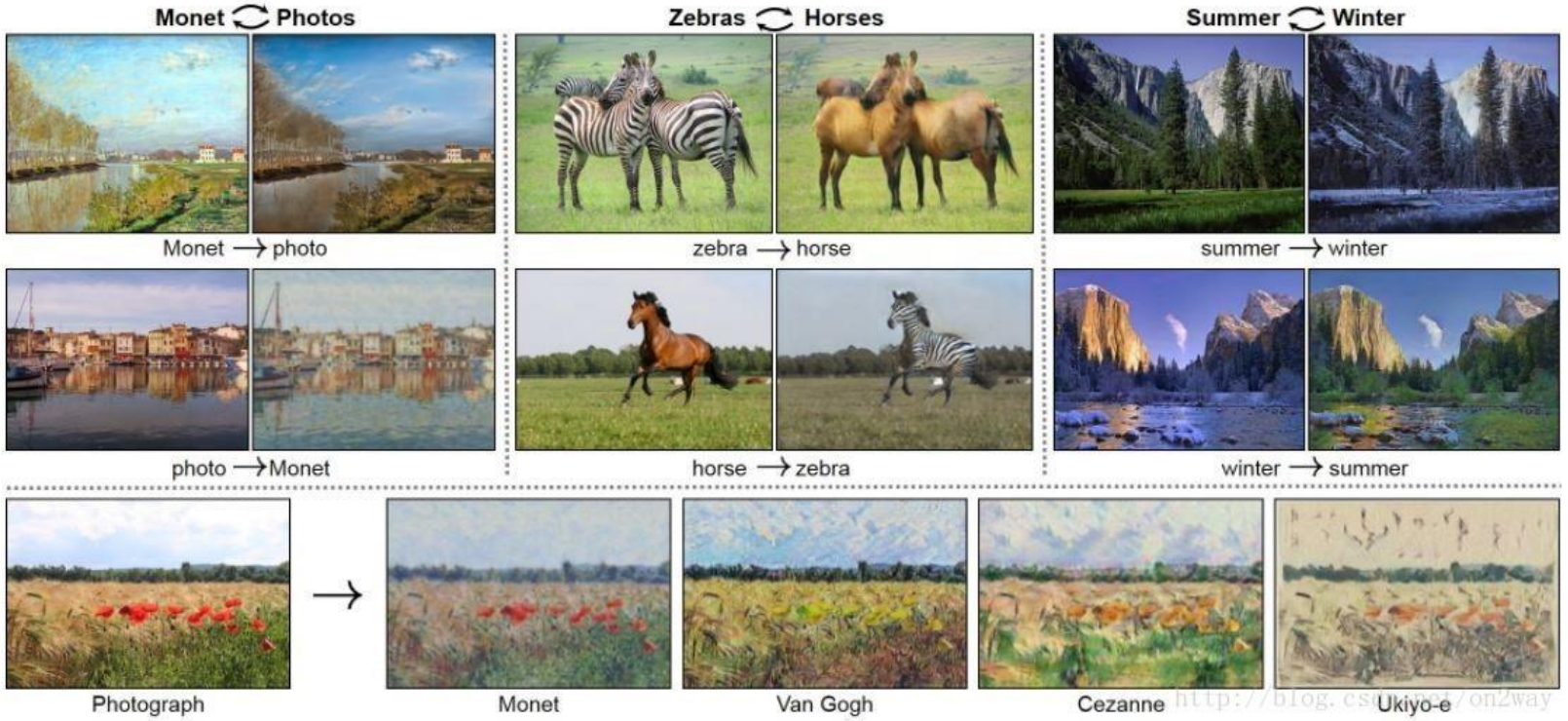


Cycle GAN (1/2)

- Cycle GAN is a neural network that can be used to generate different style/material transformations. Applied to image-to-image transformation
- Horse ⇔ Zebra



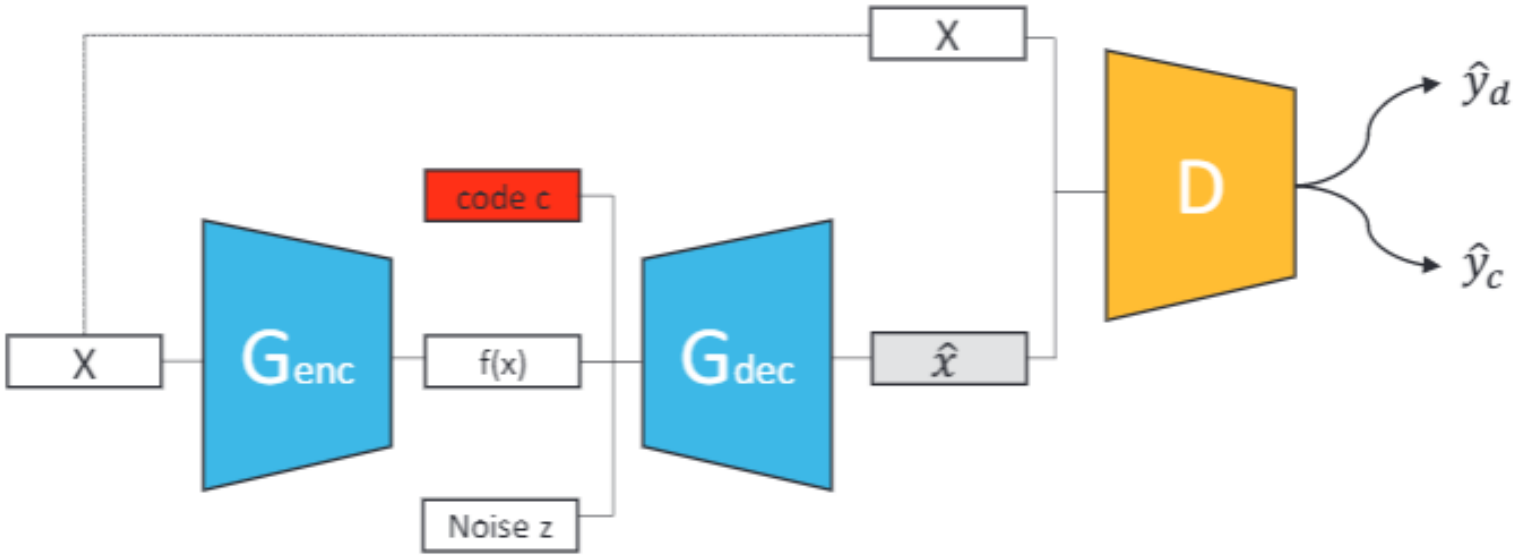
Cycle GAN (2/2)



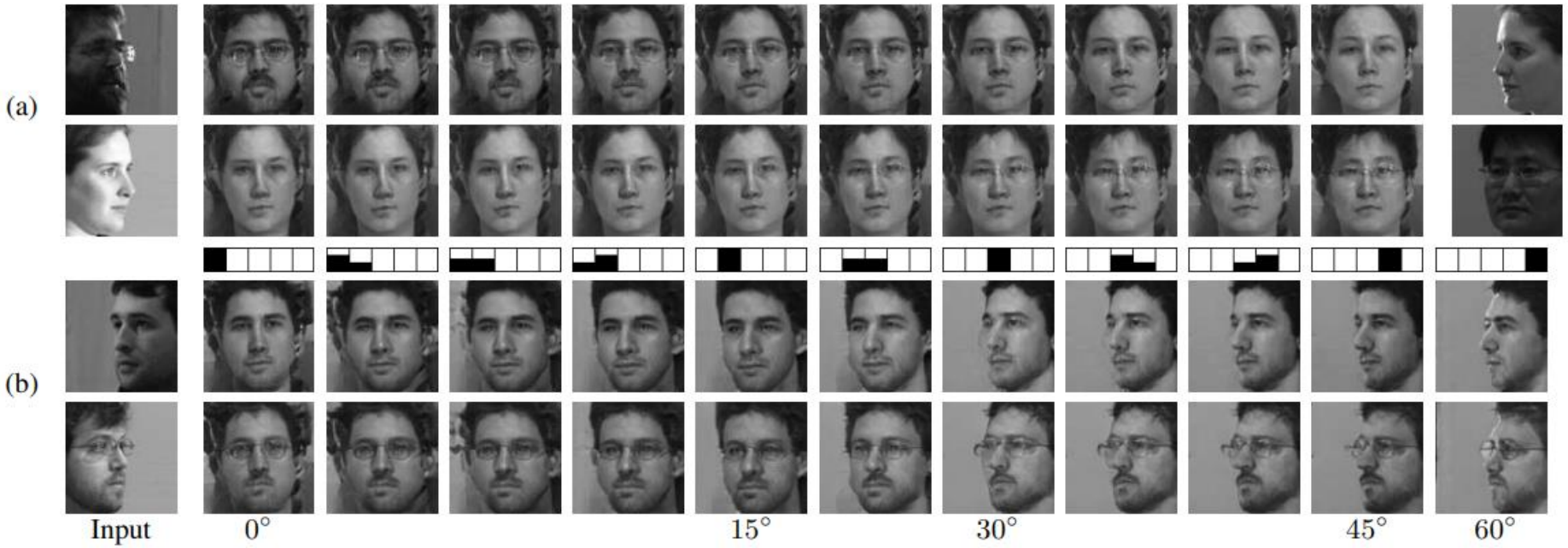
https://medium.com/hoskiss-stand/cycle-gan-note-bd166d9ff176

DRGAN (1/2)

- Disentangled Representation Learning GAN (DR-GAN)
- Add pose code in GAN.
- DRGAN can merge two faces or turn the face away.



DRGAN (2/2)



L. Tran, X. Yin, and X. Liu, “Disentangled representation learning gan for pose-invariant face recognition,” inProceedings of the IEEE conference on computervision and pattern recognition, 2017, pp. 1415–1424